

# Angra Neutrino Project: status and plans\*

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We present the status and plans of the Angra Project, a new nuclear reactor neutrino oscillation experiment, proposed to be built in Brazil at the Angra dos Reis nuclear reactor complex. This experiment is aimed to measure  $\theta_{13}$ , the last unknown of the three neutrino mixing angles. Combining a high luminosity design, very low background from cosmic rays and careful control of systematic errors at the 1% level, we propose a high sensitivity multi-detector experiment, able to reach a sensitivity to antineutrino disappearance down to  $\sin^2 2\theta_{13} = 0.006$  in a three years running period, improving present limits constrained by the CHOOZ experiment by more than an order of magnitude.

## 1. Introduction

The neutrino oscillation phenomena still depends on three unknown parameters: mixing angle  $\theta_{13}$ , sign of  $\Delta m_{13}^2$ , and the CP phase  $\delta$ . Measurement of  $\theta_{13}$  in appearance experiments, such as the ones based on accelerator, are subjected to suffer from the so called parameter degeneracies due to the effect of the unknown sign of  $\Delta m_{13}^2$  and the CP phase  $\delta$  in neutrino oscillations [1].

The reactor neutrino short baseline experiments can produce a clear oscillation signal and measure  $\theta_{13}$  with no ambiguities or matter effects [2]. In this paper we describe the main features and parameters of the Angra Experiment, a project to measure antineutrino disappearance at the Angra dos Reis Nuclear Complex (RJ - Brazil).

## 2. Angra dos Reis: The reactor complex and site main features

Angra dos Reis is a city located about 150 km south of Rio de Janeiro. At 30 km from the city there is the nuclear complex, having two operational reactors (Angra-I and II). The state owned company Eletronuclear is responsible for the general management and commercial operation of the plant. The thermal power of the reactors are 2 GW and 4 GW for Angra I and II, with uptime around 83% and 90%, respectively. The topology of the surrounding terrain, formed by mountainous granite, is an advantage of the site. The required overburden can be achieved by construction of horizontal tunnels with lower cost than vertical shafts.

## 3. The experimental design

The Angra experiment will consist of 2 neutrino detectors in the standard near/far config-

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uration. The detectors should be built in the 3 volume design: i) the central target filled with liquid scintillator doped with gadolinium; ii) the surrounding volume filled of standard scintillator (gamma catcher) and iii) the non-scintillating buffer, with same optical properties of the innermost zones, shielding the radioactive from outside. The photo-tubes will be installed on the outer wall of the buffer. The near site location is 300 m from the reactor core. We plan to place a 50 ton target detector in a 100 m depth shaft providing 250 m.w.e. of overburden. At a distance of 1.5 km from the reactors there is a 700 m granite peak of the so called "Morro do Frade". The installation of the 500 ton far detector under this peak (2000 m.w.e.) provides an effective combination of detector distance and overburden that increases the expected signal to noise ratio. In addition, we intend to include a 1 ton very near detector, at 50 m from the core, for flux precise monitoring, accurate spectral shape measurement and general cross checks.

#### 4. Experimental Reach

Preliminary estimations of the signal and background rates and are shown in Table 1.

Detector	Very Near	Near	Far
Signal	1800	2500	1000
Muons (Hz)	150	$\sim 30$	0.3
$^9\text{Li}$ bkg	44	$\leq 20$	$\sim 2$

Table 1

The Angra Experiment expected rates. Signal and  $^9\text{Li}$  background (correlated noise) are in events/day units.

The expected sensitivity as function of integrated luminosity is shown in Figure 1. The assumed value of  $\Delta m_{13}^2$  is indicated in the figure. The calculations were performed by minimizing the  $\chi^2$  formulae built to take into account four different types of systematic errors  $\sigma_{ij}$  with assumed values indicated in the figure. The subscripts D(d) represents errors correlated (uncorrelated) between detectors and B(b) errors correlated (uncorrelated) between bins of the measured energy spectra [3]. As can be seen a limit

of  $\sin^2 2\theta_{13} = 0.006$  at 90% confidence level can be achieved within three years.

#### 5. Status and plans

We are currently developing the very near detector, that will serve as prototype to test detector elements and performance and also as survey tool for systematic studies. This detector will also be used to monitor the reactor activity, and to provide an additional tool on verification of safeguards on Non-Proliferation. The planned turn-on dates are 2008 for the very near detector and 2013 for the Angra complete configuration.

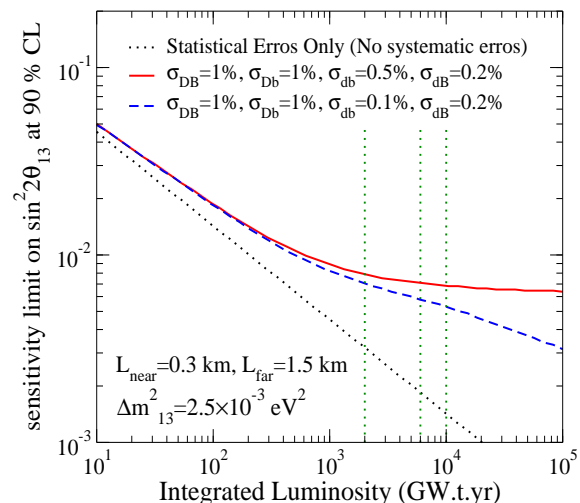


Figure 1. Sensitivity limit as a function of integrated luminosity. Vertical dashed lines represent 1, 3 and 5 years of data taking.

#### REFERENCES

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